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(54) A TOOL FOR ENLARGING THE ENDS OF PIPES

(71) We, ROTHENBERGER GmbH & Co., Werkzeuge—Maschinen KG., a German Company of 6000 Frankfurt am Main—1, Heidelberger Strasse 13, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a tool for enlarging the ends of pipes. A tool for this use has already been proposed (German published as-filed specification No. 1,752,461), and comprises a toolholder body containing an axially movable mandrel having a tapering end and capable of being displaced by an externaly applied force, and a toolhead which is exchangeably attachable to the toolholder body coaxially with the mandrel and which contains a plurality of expanding members in the form of cylinder segments radially displaceable by the axial displacement of the mandrel and so mounted that they project axially from the toolhead, the segment edges facing the mandrel forming a recess corresponding to the mandrel taper.

In the above tool the axial displacement of the mandrel inside the toolholder body is effected by a cam which cooperates with the rear face of the mandrel at the opposite end to that forming the elongated tapering end, and which is operable by a lever arm carrying a handle or grip. A second arm carrying a handle is fixed to the body of the tool. Hence the arrangement functions like a pair of caliper tongs from which the tapering end of the mandrel laterally projects. The toolhead containing the above defined expanding segments can be exchangeably screwed to the toolholder body. When the two arms are manually pressed together they cause the mandrel to be displaced into the tapering recess in the centre of the annulus of expanding segments which are therefore forced radially apart. A pipe end fitted over the expanding segments will thus be enlarged sufficiently for it to receive the spigot end of another pipe. It will be apparent that, depending upon the material of which the pipes are made, considerable expanding forces must be generated.

Exchangeability of the toolhead is necessary to permit toolheads in which the overall diameter of the annulus of expanding segments differs to be attached to the same toolholder body. However, the annulus of expanding segments must have a minimum overall diameter dictated by the major diameter of the mandrel. Otherwise the expanding segments would be too slim and lack the necessary mechanical strength to withstand the very high bending moments that arise. It is therefore the aim to keep the major diameter of the mandrel for a given angle of taper as small as possible in order to preserve the necessary mechanical strength. This has the undersirable result of impairing the functional reliability of the tool and of reducing the life of the expanding segments, this result being inherent in the manner in which the expanding segments are produced to endow them with the property of expandability.

The expanding segments are made from a solid cylindrical blank which is provided with an axial conical recess corresponding to the conically tapering end of the mandrel. An annular flange at one end of the cylinder serves for subsequently retaining the segments in the toolhead. However, for the purposes of the present explanation this flange need not be taken into account. The cylinder containing the coned recess is then cut into say six equal segments. This is done with a sawblade which produces a specially wide cut because the material which the sawblade removes is intended to create the necessary gap that will enable the annulus of segments to be pushed radially closer together. In this contracted state the segments can then be inserted into the unexpanded end of a pipe for the purpose of being forced apart by the mandrel with the simultaneous enlargement of the pipe end. The segments are thus expanded until they attain the relative positions they originally occupied in the solid cylindrical blank from which they were cut. Fine castings

produced to comply with these geometrical conditions that have been described would, of course, be equivalent.

However, the removal of material during the sawcut results in a significant reduction of the narrow surface areas that make contact with the mandrel. The sawcut moves the end of the conical recess from the bottom of the segments further up into the interior of the annulus of segments, and the mandrel which is forced into the interior of this annulus will not therefore make contact with a surface that extends from the top to the bottom end of each segment. This means that the specific contact pressure will be much higher, with a concomitant higher rate of wear and a tendency of the segments to tilt or of laterally slipping off the mandrel surface. Besides, a corresponding bending moment involving the unsupported projecting ends of the segments which are not backed by the tapering end of the mandrel will arise. Whereas this is a state of affairs that may be acceptable when the expanding segments are fairly small, the problems become more significant as the diameter and length of the segments increase, assuming these segments are designed to cooperate with the same (small) mandrel. The expanding segments must necessarily define a great diameter if they are to be used for wider gauge pipes which usually also have a thicker wall, so that the magnitude of the radial expansion of the segments must also be correspondingly greater. This increased distance of radial separation necessitates the removal of more material during the subdivision of the cylindrical blank into the several segments and consequently the remaining surface available for contact with the tapering end of the mandrel will become unacceptably small.

The problem might be solved by using a toolholder body containing a larger mandrel, but this would preclude attaching the tool to a toolhead containing smaller expanding segments. For the great diversity of possible applications, i.e. for pipes of a wide range of diameters, several expanding tools would therefore have to be kept available and the advantage afforded by the exchangeability of the toolhead containing the expanding segments would partly be lost.

It is therefore an object of the present invention to improve a tool of the hereinabove specified kind in such a way that the range of applicability of the tool with regard to the attachability thereto of small and large toolheads is enlarged.

According to the invention this object is achieved by the provision of a tool for enlarging the ends of pipes, comprising a toolholder body containing mandrel capable of being displaced axially by an externally applied force and having a tapering end, a toolhead which contains a plurality of expanding members in the form of cylinder segments so mounted that they project axially from the toolhead, and an adapter removably mountable between the toolholder body and the toolhead and comprising an adapter body containing an axially displaceable supplementary mandrel having at one end a recess shaped to receive the tapering end of the mandrel in the toolholder body and its other end being tapered to cooperate with the cylinder segments of the toolhead and displace the cylinder segments radially upon axial displacement of the toolholder mandrel, the segment edges facing the adapter mandrel forming a tapered recess corresponding to the taper of the tapered end of the adapter mandrel.

The provision of the adapter greatly widens the utility range of the tool by permitting a large number of different toolheads having expanding segments of different sizes to be attached to the toolholder body. The utility range can be widened in different respects. In the first place the mandrel and the supplementary mandrel may both have tapering ends having the same angle of taper. The built-in mechanical advantage of the tool is not thereby altered, i.e. the ratio of the mandrel displacement to radial width of expansion remains the same. Alternatively the conically tapering end of the adapter mandrel may be provided with a different angle of taper, for instance with smaller angle of taper, than that of the mandrel in the toolholder body. This improves the mechanical advantage and permits the process of expansion to be accomplished with the expenditure of less effort. Such a step is particularly useful in a tool comprising a double lever mechanism as described in the prior specification already referred to above.

The adapter permits the use of toolheads having larger expanding segments in conjunction with toolholders having a small primary mandrel, or conversely, for the purpose of adapting the diameter of the mandrel optimally to the size of the expanding segments that are to be used. In the first of the two above alternatives the adapter mandrel may with advantage have a larger diameter at the base then the primary mandrel of the tool. This permits the internal coned recess inside the annulus of expanding segments to be substantially larger, the contacting surfaces between mandrel and expanding segments to be increased and, primarily, the surface contacting the mandrel to extend down the full length of the segments. The increased area of contacting surface improves the conditions of friction which would reduce the thrust and the expanding force. Moreover, the annulus of expanding segments is more satisfactorily centralised, and this prevents the segments from slipping

off laterally. Moreover, manufacturing tolerances when producing the expanding segments by dividing a solid cylindrical blank are more easily bridged. In the case of a very small mandrel even the lightest lateral malalignment of a dividing slot would enhance the tendency of the segments to slip laterally off the mandrel. The provision of favourable frictional conditions is particularly useful because the proposed tool is principally used on building sites where maintenance usually leaves much to be desired.

Another advantage will be secured if the adapter is provided with a restoring spring which operates to retract the adapter mandrel into the body of the adapter. Prior art tools lack such a restoring spring and the recontraction of the expanding segments must often be assisted by tapping them with a hammer. The mandrel inside the expanding segments is often an impediment since it may be prevented from withdrawing by reason of its taper being within the limiting angle of friction. The presence of a restoring spring will ensure that the expanding segments will readily yield radially inwards. The adapter will therefore also prove useful when the diameters of the primary mandrel and of the supplementary adapter mandrel are equal, in as much as the restoring spring facilitates handling the tool.

In a preferred arrangement the restoring spring may be so contrived that it is effective only within the final part of the displacement of the adapter mandrel. The resistance of the restoring spring meed not then be overcome during the first part of the displacement of the mandrel in expanding direction. The additional effort needed towards the end of the displacement of the mandrel is less objectionable. However, the presence of a restoring spring which takes effect during the last part of mandrel displacement assists engagement of the pawl in a double lever mechanism, as described in the prior art tool.

The adapter is by no means an expensive component. It is preferred that the adapter and its mandrel should substantially both be axially symmetrical, i.e. bodies of revolution, one end of the adapter body being threadedly attachable to the toolholder body and the other end to the toolhead. Screw type joints are not the only possible type of joint for this purpose. For example, push-and-turn types of joint would also be feasible.

Furthermore, with particular advantage the tapering end of the adapter mandrel need not be conical, but may instead have a polygonal pyramidal taper which is arranged to match the internal taper recess in the annulus of expanding segments, i.e. this internal taper would likewise define a hollow polygonal pyramid, the edges of the pyramid coinciding with the divisional gaps between neighbouring segments. The contacting faces in this case would be completely flat and thus always ensure the creation of flush contact at the highly loaded sliding interfaces in any relative position of mandrel and segments. This reduces the specific surface pressure and improves lubrication. Moreover, the segments cannot slip off the mandrel faces in the sideways direction. Consequently, the effort needed for operating the tool will be less and the life of the tool will be longer.

Suitable polygonal pyramids might be four-sided, hexagonal or octagonal and their angles at the vertex could be chosen from within a wide range of angles. As a precaution the top of such a pyramid will usually be cut off so that technically the pyramid will be truncated.

In order to permit the toolhead to be screwed to the adapter it may in such a case be desirable to interpose a rotary joint between the pyramidal tapering end of the mandrel and the mandrel body, but this is by no means essential since, generally speaking, the adapter mandrel will already be freely rotatably mounted in the adapter body.

By using an adapter which provides a "cone-to-pyramid" coupling it is possible to modify existing tools—i.e. toolholders—to operate toolheads designed for pyramidal mandrels in order to secure the above mentioned advantages.

Some preferred embodiments of the invention and the manner in which the proposed tools function will now be more particularly described with reference to the accompanying drawings, in which

Figure 1 is an axial section of a toolholder without a toolhead,

Figure 2 is an axial section of a toolhead containing expanding segments, and designed to be screwed to the toolholder shown in Fig. 1,

Figure 3 is an axial section of an adapter fitted with a mandrel of greater diameter than that in Fig. 1,

Figure 4 is an axial section of a toolhead having larger expanding segments than those in Fig. 2, suitable for use in conjunction with the adapter mandrel in Fig. 3,

Figures *5a* and *5b* are cross section taken on the lines V*a*—V*a* and V*b*—V*b* Figures 2 and 4 respectively,

Figure 6 is a perspective view of an expanding jaw for a mandrel which in principle would be relatively too small,

Figure 7 is a perspective view of an expanding segment for a mandrel of appropriate size,

Figure 8 shows a modification of the ad-

apter according to Fig. 3, fitted with a pyramidal mandrel,

Figure 9 is a perspective view of an annulus of expanding segments appropriate for use with the adapter in Fig. 8, and

Figure 9*a* is a single expanding segment of the annulus in Fig. 9.

Referring to Figure 1 there is provided a substantially axially symmetrical toolholder body 10 provided at its bottom end with screw threads 11. The toolholder body 10 is formed with a laterally projecting arm 12 provided at its end, not shown, with a handle or grip. The toolholder body 10 is provided with an axial bore 13 axially slidably containing a mandrel 14. The mandrel has an elongated conically tapering and 15 which projects from the toolholder body 10. The rear end of the mandrel 14 has a head 16 with a flat surface 17 for cooperation with the peripheral face of a cam 18 formed on a lever 19 which at its end is likewise fitted with a handle, not shown. The cam 18 and the lever 19 are mounted on a pivot pin 20 in lug-shaped bearings 21 at the upper end of the toolholder body 10. This lever 19 can be deflected for instance in the direction indicated by an arrow 19*b* into a position 19*a*, in which case the cam 18 will be turned into a position 18*a*. In this position the mandrel 14 can yield in the arrowed direction upwards.

A toolhead generally marked 22 in Figure 2 is attachable to the toolholder body shown in Figure 1. This toolhead comprises a sleeve 23 containing an internal screw thread 24 which fits the external screw thread 11. The lower part of the sleeve 23 contains an internal peripheral recess 25 and a central opening 26 for the reception of six expanding segments 27 of which only three are shown in the drawing. The expanding segments 27 have a part cylindrical peripheral suface 28, but in the illustrated position the peripheral sufaces of all the expanding segments do not in combination define a common cylindrical surface. This will be explained later with reference to Figure 5. The ends of the expanding segments which are contained inside the sleeve 23 are each provided with a flanged edge 29 containing a groove and all the grooves together peripherally embrace the segments for the reception of a split spring ring 30. This spring ring pulls the expanding segments as closely as possible together, i.e. into the position illustrated in Figure 2.

Substantially the expanding segments 27 are complete segments from which portions 31 are machined away on the inside. When the segments are forced apart these portions define a conical recess which matches the tapering end 15 of the mandrel 14. When the mandrel end 15 enters the conical recess 31 the expanding segments 27 will therefore be forced apart in the directions indicated by two horizontal arrows, causing a pipe end which may have been pushed over the contracted segments to be correspondingly enlarged. It will be understood that the conical recess 31 extends down only part of the axial length of the expanding segments 27, namely from the top downwards to a point determined by the machining operation and based on the desired function of the segments as will be further explained in connection with Figures 5 to 7. In any event the continued descent of the end 15 of the mandrel 14 into the annulus of segments does not afford further support to the freely projecting ends of the expanding segments 27 which are therefore subjected to bending stress. The arrangement shown in Figure 2 illustrates the smallest possible toolhead for a mandrel 14 of the kind shown in Figure 1. It will be readily appreciated that the magnitude of the contacting surfaces in the recess 31 and the position of the apex at 32 would not change if the expanding segments were enlarged (in diameter and length). However, the operating forces and hence the frictional and bending forces would increase considerably. These circumstances will be readily apparent if it is imagined that a much larger toolhead such as that in Figure 4 provided with an internal recess 31 equal in size to that in Figure 2 were associated with a tool such as that illustrated in Figure 1.

Figure 3 illustrates the adapter 33 the invention proposes to provide. Adapter 33 consists of an adapter body 34 containing an axially movable supplementary mandrel 35 of which the bottom end 36 has an elongated conical taper 36, whereas the other end contains a conical recess 37 suitable for the reception therein of the end 15 of mandrel 14 when the adapter body 33 is attached by means of its internal screw threads 38 to the toolholder body 10. The vertex angle of the conically tapering end 36 equals that of the conical end 15. The mandrel 35 may have a smaller diameter than the mandrel 14 but preferably, and as shown, the major diameter of the adapter mandrel 35 is greater by a factor of 1.5 than the major diameter of the mandrel 14. The adaptor in Figure 3 is therefore suitable for cooperation with a larger toolhead, such as that shown in Figure 4. Interposed between the adapter 34 and the adapter mandrel 35 is a restoring spring 39 which has a suitably steep spring rate, but which is so short that it takes effect only during the final part of the displacement of the adapter mandrel 35 by coming into contact with a collar 40 on the adapter mandrel. An additional much weaker spring, not shown in the drawing, may be provided to keep the adapter mandrel 35 in the illustrated position in which the collar 40 bears against a retaining ring

41 inside the adapter body 34. The conically tapering end 36 projects a corresponding distance from the body 34 of the adapter analogously to Figure 1.

In Figure 4 parts corresponding to parts in Figure 2 are identified by the same reference numbers, amplified by the suffix "*a*" where these parts have substantially larger dimensions. It will be understood that the internal conical surface 31*a* of the recess extends down the entire length of the expanding segments 27*a* to a point 32*a*, i.e. much further down than in Figure 2 where the segments are intended for cooperation with the shorter tapering end 15 of mandrel 14. This arrangement provides the above discussed advantages. By means of its threads 24 the larger toolhead 22*a* is screwed to the threads 42 on the adapter 33 which is itself attached to the toolholder body 10 in Figure 1 by engagement of the threads 38 with the threads 11 on the body 10.

In Figure 5*a* which is a section taken on the line V*a*—V*a* in Figure 2 the expanding segments 27 are shown in expanded position in which their part cylindrical peripheral surfaces form parts of the common cylinder surface. This cylinder surface corresponds to the cylinder surface of a round section blank from which the segments have been produced. The conical recess 31 is produced first. A gap of width "*s*" is then cut with a saw blade which makes a cut of appropriate width. This gap provides the space needed for later pushing the segments together. The effect of making such cuts of width "*s*" is shown in Figure 6. The bottom end of the conical recess 31 which has originally reached the bottom end "E" of each segment is displaced upwards to point 32 which is also the end of the surface which makes contact with the conical peripheral surface 15 of the mandrel 14. The portion from point 32 down to "E" will not therefore be in contact with the mandrel and will be subjected to a lever effect. It is apparent that the contacting surface of the recess 31 which is shaded is considerably reduced by the removal of material during the formation of the slot.

The expanding segment according to Figure 7 is based on the production principle illustrated in Figure 5*b*, in which the recess 31*a* corresponds to the much larger base diameter of the tapering end 36 of the adapter mandrel 35. Notwithstanding the removal of the material when the cylindrical blank was divided into several segments the bottom end of the shaded contacting surface of the recesses 31*a* still extends to the bottom end E of the expanding segment. That advantage can be taken of this possibility is entirely due to the provision of the adapter 33. Tolerational variations have a corresponding smaller effect.

In Figure 8 parts corresponding to parts in Figure 3 are again identified by the same reference numbers. The end 36*a* of the adapter mandrel 35 in this embodiment is, however, shaped like a hexagonal pyramid attached to the body of the adapter mandrel 35 by a rotary coupling. This coupling consists of a pivot pin 43 projecting from the base of the pyramid into the body of the adapter mandrel. The pyramid is prevented from falling off by a spring ring not visible in the drawing. By making suitable allowances provision is made for slight lateral pendulum movements of the end 36*a* to enable minor axial misalignment to be absorbed.

Figure 9 shows an annulus of expanding segments 27*b* having flanged ends 29*b* and a recess 31*b* matching the geometry of the polygonal end 36*a* of the adapter mandrel, i.e. the triangular face of the recess on the internal edge of each segment, which is clearly visible in Figure 9*a*, is flat-contrary to the corresponding surfaces in Figs. 6 and 7.

WHAT WE CLAIM IS:—

1. A tool for enlarging the end of pipes, comprising a toolholder body containing a mandrel capable of being displaced axially by an externally applied force and having a tapering end, a toolhead which contains a plurality of expanding members in the form of cylinder segments so mounted that they project axially from the toolhead, and an adapter removably mountable between the toolholder body and the toolhead and comprising an adapter body containing an axially displaceable supplementary mandrel having at one end a recess shaped to receive the tapering end of the mandrel in the toolholder body and its other end being tapered to cooperate with the cylinder segments of the toolhead and displace the cylinder segments radially upon axial displacement of the toolholder mandrel, the segment edges facing the adapter mandrel forming a tapered recess corresponding to the taper of the tapered end of the adapter mandrel.

2. A tool according to Claim 1, wherein the tapered ends of the two mandrels have the same angle of conical taper.

3. A tool according to Claim 2, wherein the diameter of the adapter mandrel is greater than that of the mandrel in the toolholder.

4. A tool according to Claim 2, wherein the adapter mandrel has the same diameter as the mandrel in the toolholder.

5. A tool according to Claim 2, wherein the adapter mandrel has a smaller diameter than the mandrel in the toolholder.

6. A tool according to Claim 1, wherein the tapered end of the adapter mandrel has a taper angle which differs from that of the

tapering end of the mandrel in the toolholder.

7. A tool according to any one of the preceding Claims, wherein the body of the adapter contains a restoring spring which operates to draw the adapter mandrel back into the body of the adapter.

8. A tool according to Claim 7, wherein the restoring spring is so designed that it takes effect only during the final part of the displacement of the adapter mandrel for forcing apart the expanding segments.

9. A tool according to any one of the preceding claims, wherein the body of the adapter and the mandrel which it contains are substantially bodies of revolution and that one end of the body of the adapter is threadedly attachable to the toolholder body, and the other end to the toolhead.

10. A tool according to Claim 1, wherein the adapter mandrel has a pyramidal tapering end.

11. A tool according to Claim 10, wherein a rotary coupling is provided between the pyramidal tapering end and the remaining portion of the adapter mandrel.

12. A tool according to Claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

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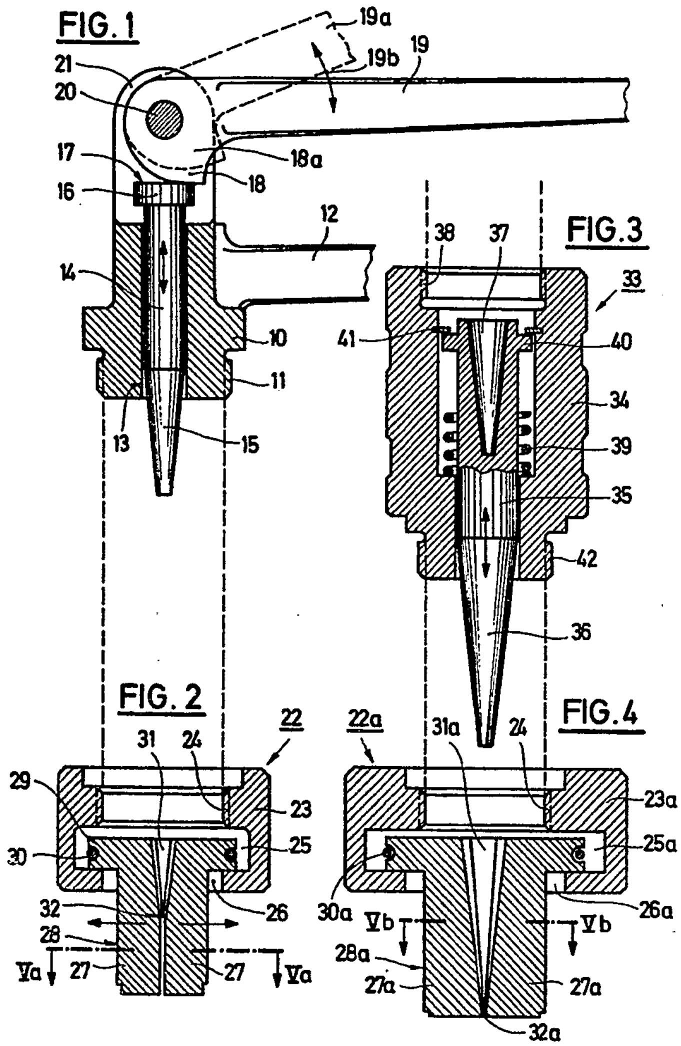


FIG. 5a

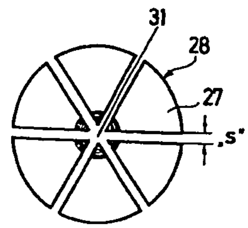
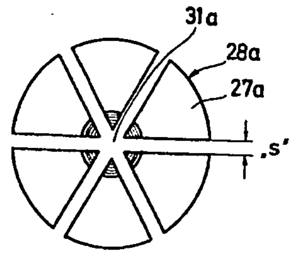


FIG. 5b



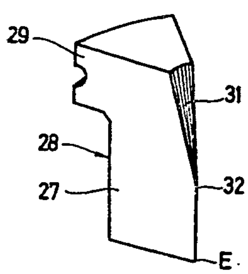


FIG. 6

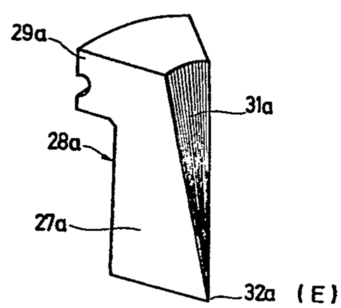


FIG. 7

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Sheet 3

FIG. 8

FIG. 9a

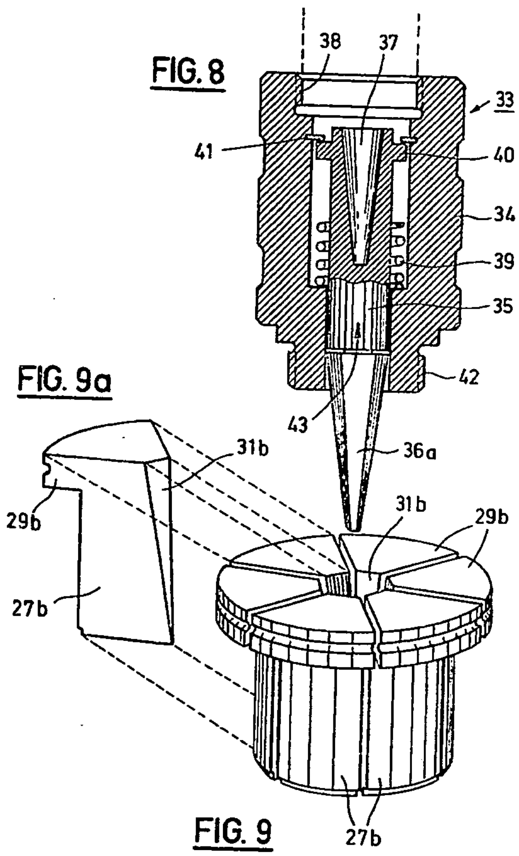

FIG. 9

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